SIMULATED WATER-LEVEL DECLINES CAUSED BY WITHDRAWALS FROM WELLS J-13 AND J-12 NEAR YUCCA MOUNTAIN, NEVADA

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CONVERSION FACTORS

Multiply	*By*	*To obtain*
meter (m)	3.281	foot (ft)
foot (ft)	.3048	meter (m)
acre-foot (acre-ft)	1,233	cubic meters (m^3)
gallon per minute (gal/min)	.00006309	cubic meters per second (m^3/s)
mile (mi)	1.609	kilometer (km)

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ABSTRACT

Simulations were done to examine the effects of ground-water withdrawals from wells J-13 and J-12 near Yucca Mountain, Nevada. These simulations were done using a two-dimensional finite-element model of the subregional ground-water flow system of Yucca Mountain and vicinity. Eight different withdrawal rates ranging from 36 gallons per minute (the minimum average for well J-13) to 1,390 gallons per minute (the maximum for both J-13 and J-12 combined) were used in conjunction with specific-yield values of 0.001, 0.005, and 0.01. Drawdown was analyzed for each withdrawal rate by plotting contours of draw-down after 10 years of simulated withdrawals, and by plotting drawdown as a function of time for model locations corresponding to well J-13, well J-12, one-half mile south of well J-12, 2 miles north of the town of Amargosa Valley, and about 5 miles northwest of the Ash Meadows area. Because the range in simulated withdrawal rate was large, the range in resultant drawdown was correspondingly large. The simulated drawdowns after 10 years for the withdrawal rate of 90 gallons per minute from well J-13, based on a specific yield of 0.01 (which was considered to be a minimum value for the aquifer system) were 0.95 foot at well J-13, 0.53 foot at Amargosa Valley, and 0.16 foot northwest of Ash Meadows.

INTRODUCTION

Yucca Mountain is being studied for its suitability as a potential site for a high-level nuclear-waste repository by the U.S. Department of Energy. The U.S. Geological Survey is participating in this study, in cooperation with the U.S. Department of Energy under Interagency Agreement DE-AI08-ET44802. As part of planned characterization activities, ground-water will be pumped to supply water for dust control and other site-characterization-related work. The U.S. Department of Energy has requested a permit from the State of Nevada to withdraw as much as 90 gal/min of water from well J-13.

Purpose and Scope

This report documents a series of eight simulations that estimate the water-level declines caused by withdrawing ground water from wells J-13 and J-12 (fig. 1), located about 2 miles east of Yucca Mountain. The period of each simulation was 10 years, which is considered a reasonable duration for

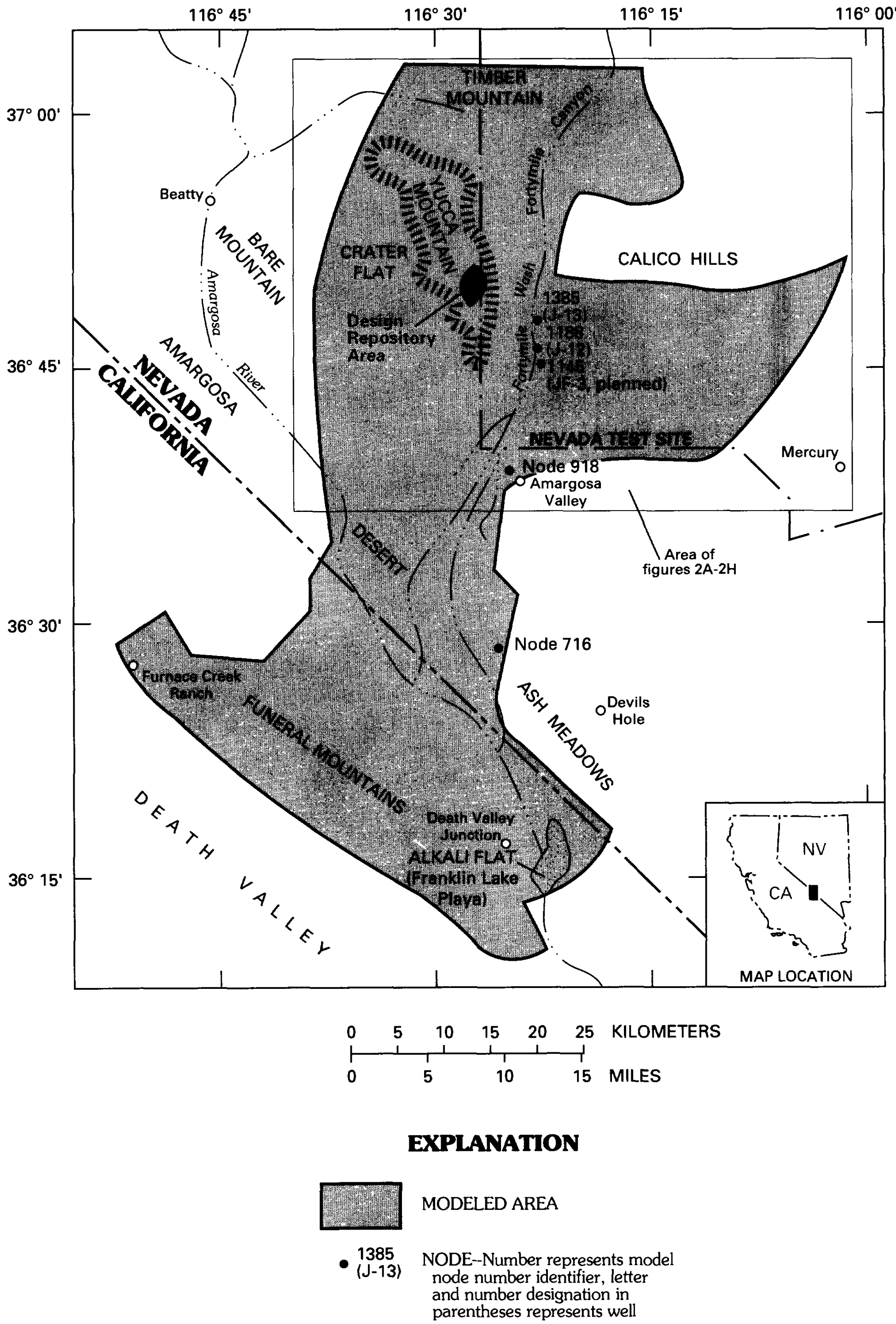


Figure 1.--Location of study area.

site-characterization activities at Yucca Mountain to be completed. The simulated maximum rates of withdrawals were limited to the current capacity of the existing pumps. The scope of the report is limited to presenting water-level changes within a radial distance of about 20 miles from well J-13.

Previous Work

Numerous workers have contributed to the understanding of the regional ground-water flow system of Yucca Mountain and vicinity; to list them here is beyond the scope of this report. Extensive analyses of aquifer test results from well J-13 were reported by Thordarson (1983) and less extensively by Young (1972). Simulations of the regional ground-water flow system were done by Waddell (1982); the smaller, subregional system was simulated by Czarnecki and Waddell (1984) and Czarnecki (1985). The model configuration and values of hydraulic conductivity from Czarnecki (1985) were used for the simulations presented in this report.

SIMULATIONS OF GROUND-WATER WITHDRAWALS

Simulations were made using the model configuration reported in Czarnecki (1985). The reader is referred to that report for specifics on model construction, boundary-condition specification, and material properties. The model was selected because it was readily available and was capable of resolving small spatial changes in water-table altitude through time over a broad region.

Several simplifications and assumptions about geology and hydrology were made to develop the model (Czarnecki and Waddell, 1984); many of these simplifications were necessary because of lack of data. These assumptions and simplifications are:

1. Ground-water flow is strictly horizontal.

2. Initial hydraulic heads represent steady-state conditions.

3. The rocks are isotropic with respect to hydraulic conductivity. Although deposition and subsequent fracturing of sedimentary and tuffaceous rocks create anisotropy with respect to hydraulic conductivity, insufficient data are available from aquifer tests to evaluate the degree of anisotropy.

The finite-element mesh and values of hydraulic conductivity and zonation that were used in the current model were identical to those used by Czarnecki (1985). As in Czarnecki (1985), a water-table simulator was used so that changes in transmissivity as a function of changing saturated thickness could be simulated. Head-dependent sinks were not specified in the current transient version of the model. All fluxes were identical to those specified by Czarnecki (1985) except for the flux at Franklin Lake playa. Instead, flux at Franklin Lake playa was specified as a combination of areally distributed flux and a specified-head node that was set at 1,978 ft (603 m). The resultant combined flux at Franklin Lake playa for steady-state conditions was

854,500 ft^3/d (24,200 m^3/d). This value agrees closely with the sum of the head-dependent sinks and specified-head node in Czarnecki (1985) and with the discharge rate estimated in Czarnecki (1990, p. 78) of 805,070 ft^3/d (22,800 m^3/d).

The current version of the computer code MODFE (Torak, 1991) was used to simulate ground-water flow; Czarnecki (1985) used the computer code FEMOD (a precursor to MODFE). MODFE was modified for the current simulations to permit reading of various pre-existing input files, particularly finite-element mesh data; the code also was modified to permit printing of hydraulic-head output at even-year time steps, even though the actual time step was 0.1 yr. This modification decreased output by 90 percent.

Methods

Prior to the simulation of the effects of withdrawals from wells J-13 and J-12, steady-state simulations with no withdrawals were done to obtain steady-state values of hydraulic head. These steady-state hydraulic heads were verified by using them as initial heads in the transient simulation and comparing them with heads after 10 years of simulation with no wells pumping. Differences between the initial head values and the final head values after 10 years with no withdrawals were 0.03 ft or less. Mass balance errors typically were four orders of magnitude smaller (or less) than the largest specified model flux for all simulations.

Table 1.--*Simulation designations and withdrawal rates*

[gal/min, gallons per minute; m^3/s, cubic meters per second]

Simulation	Withdrawal Rate				Source of withdrawal rate
	Well J-13		Well J-12		
	(gal/min)	(m^3/s)	(gal/min)	(m^3/s)	
A	36	0.00227	0	0	DOE permit application
B	90	.00568	0	0	DOE permit application
C	84	.00530	39	.00246	1988 average rate combined with simulation A
D	90	.00568	39	.00246	1988 average rate for J-12 with simulation B
E	138	.00871	39	.00246	1988 average rate combined with simulation B
F	630	.00397	0	0	Current capacity of pump in well J-13
G	0	0	760	.0479	Current capacity of pump in well J-12
H	630	.00397	760	.0479	Combination of simulations F and G

Various withdrawal rates were simulated to examine different stresses on the hydrologic system. These withdrawal rates and corresponding simulation designations are shown in Table 1. A withdrawal rate of 36 gal/min at well J-13 (simulation A) is the average rate resulting from withdrawing 400 acre-feet of water over a period of 7 years, a quantity shown in an attachment to the U.S. Department of Energy's permit application (application number 52338 before the Nevada State Engineer). Simulation B used a withdrawal rate corresponding to 90 gal/min at well J-13, which also was specified by the U.S. Department of Energy in its permit application. Simulation C is the result of adding the 1988 average withdrawal rates from well J-13 (48 gal/min) and well J-12 (39 gal/min) to the withdrawal rate from simulation A. Average withdrawal rates for 1988 were the most recently available data on current usage. Simulation D represents a withdrawal rate of 90 gal/min from well J-13 combined with the 1988 average withdrawal rate for well J-12. Simulation E represents the combination of the 90 gal/min withdrawal rate at well J-13 plus the 1988 average rates at wells J-13 and J-12. Simulation F represents the maximum pumping capacity of well J-13, limited by the size of the existing pump. Simulation G represents the maximum pumping capacity of well J-12. Simulation H represents the combination of the maximum pumping capacities from wells J-13 and J-12. All simulations were run for a period of 10 years.

For each withdrawal rate, simulations were made with model values of specific yield set at 0.001, 0.005 and 0.01. The value of 0.01 was considered the likely minimum value for specific yield based on values of effective, or interconnected, porosity (2.8 to 8.7 percent) reported in Thordarson (1983, table 8, p. 18). In addition, Young (1972, p. 13) reports a conservative estimate of specific yield of more than 0.05. Values of 0.005 and 0.001 were considered to be extremely conservative estimates of specific yield. Few data are available regarding aquifer storage near Yucca Mountain, due largely to the wide spacing of wells and the difficulty in measuring changes in water levels among these wells that result from pumping any specific well.

Results

Maps showing water-level declines for the various withdrawal rates in table 1 are shown in figures 2*A-H*, and were made from simulations with a specific yield of 0.01, which was considered to be a minimum regional value. These maps focus on the northern part of the modeled area because the potential effects are largest between well J-13 and the town of Amargosa Valley (formerly known as Lathrop Wells). These maps were constructed by subtracting the steady-state initial hydraulic head from the value of hydraulic head at the end of year 10 of the simulation for each node in the finite-element mesh. A computer program was used to produce the contours. Hatchuring only appears on closed contours. Figures 2*A-E*, which have a contour interval of 0.1 ft, have a slight cone of depression around the pumped well. Figures 2*F-H*, which have a contour interval of 0.5 ft, have a more pronounced cone of depression around the pumped well (or wells). Drawdown increases with increasing withdrawal rates.

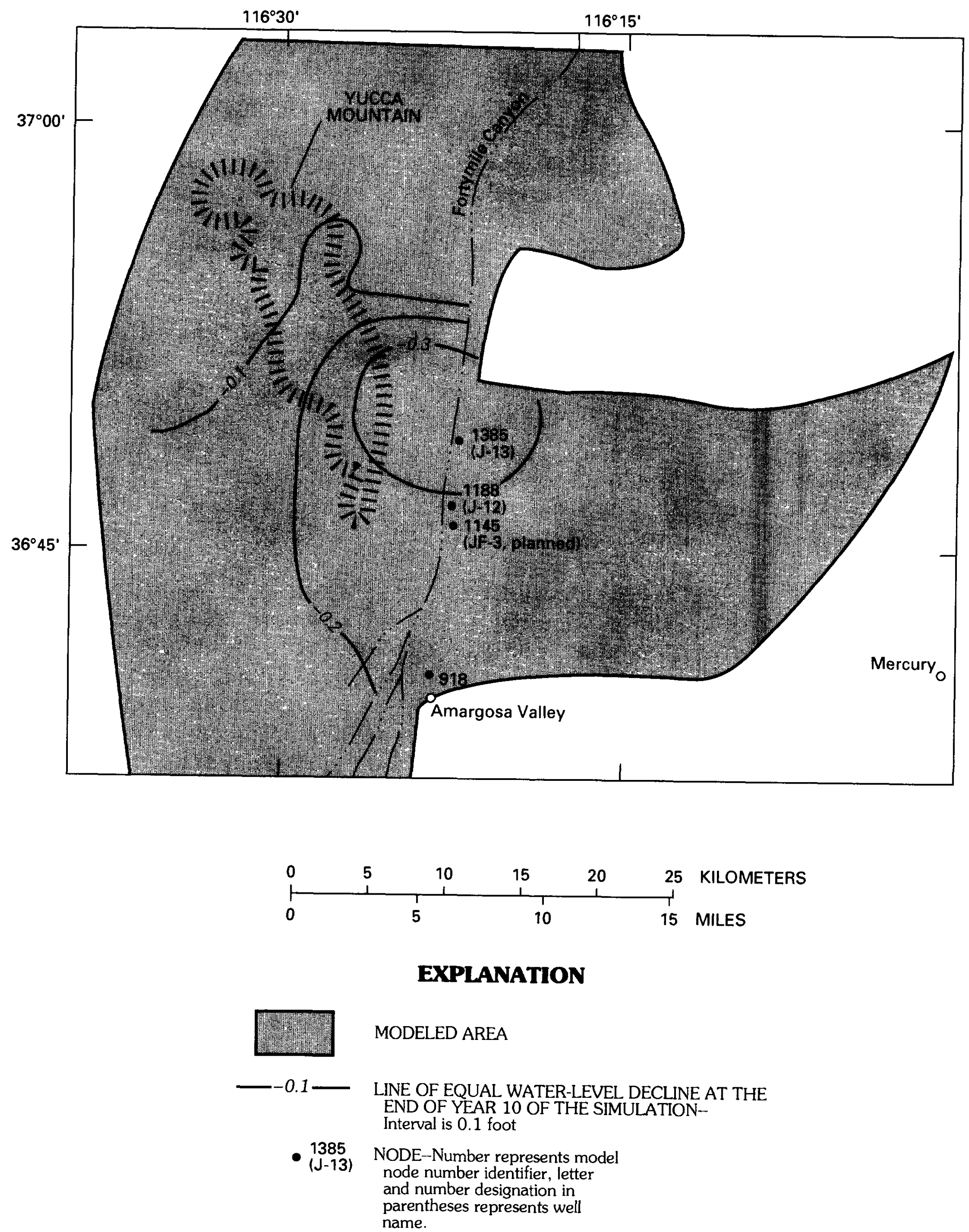
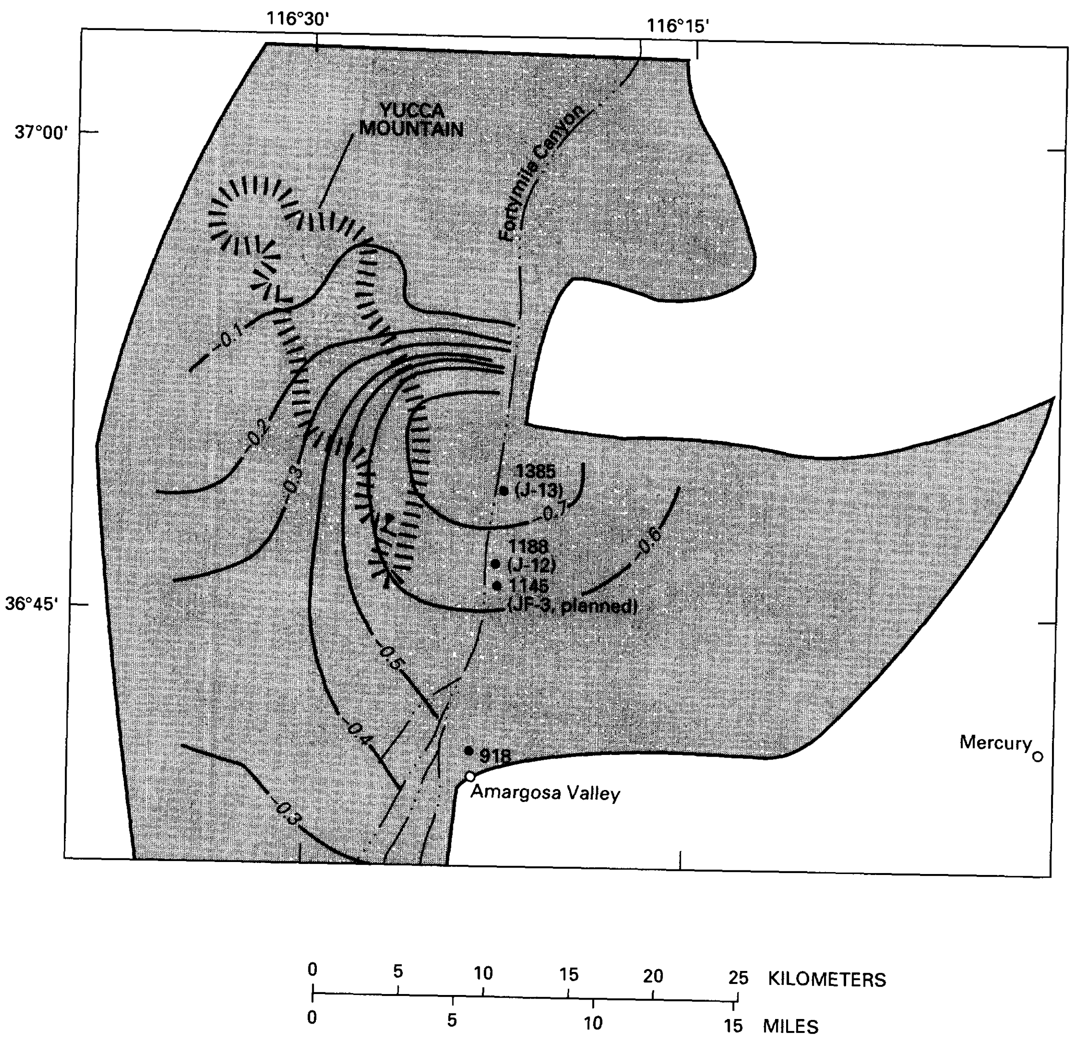


Figure 2A.--Simulated water-level decline caused by well J-13 pumped at 36 gal/min for 10 years.



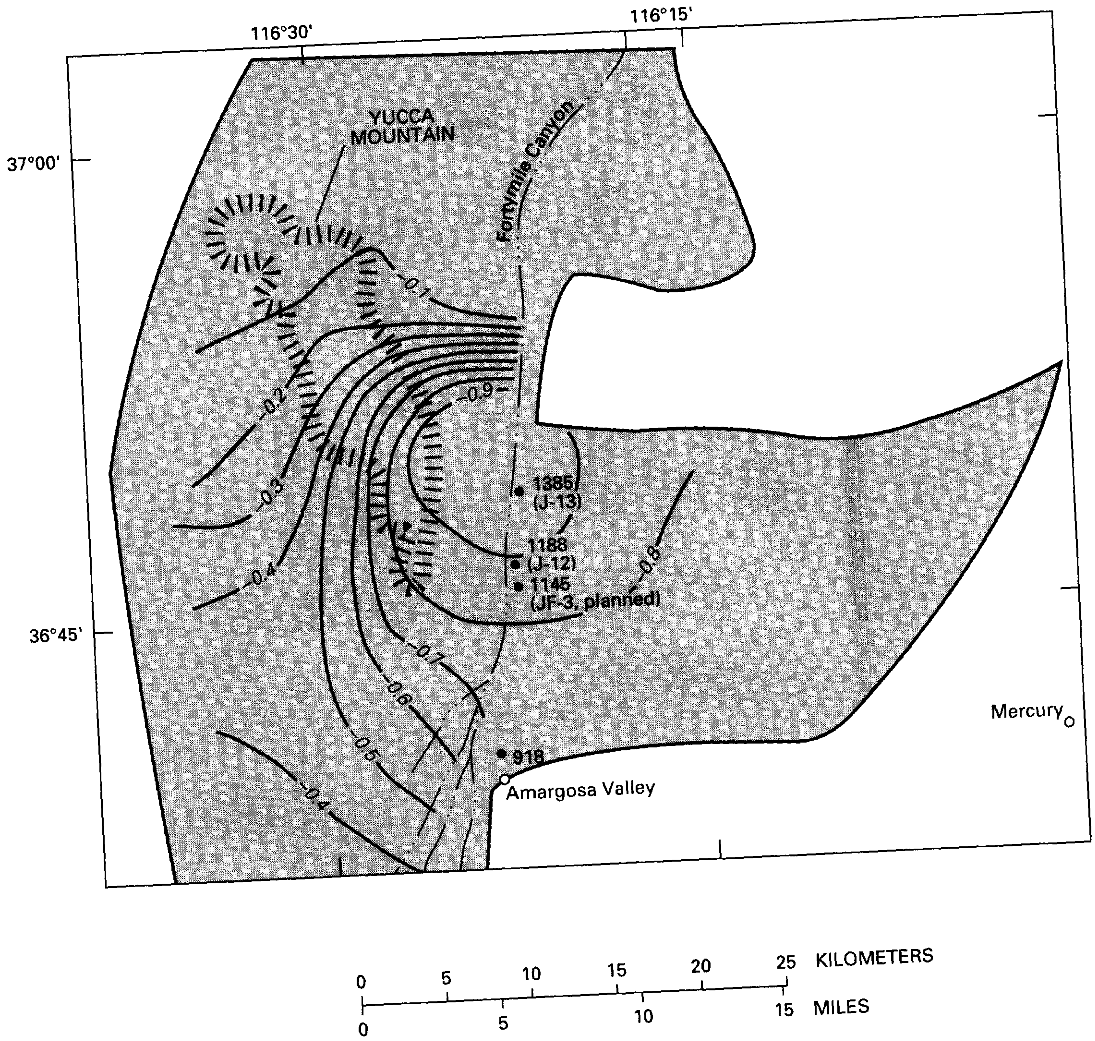
EXPLANATION

MODELED AREA

—*-0.1*— LINE OF EQUAL WATER-LEVEL DECLINE AT THE END OF YEAR 10 OF THE SIMULATION--Interval is 0.1 foot

• 1385 (J-13) NODE--Number represents model node number identifier, letter and number designation in parentheses represents well name.

Figure 2*B*.--Simulated water-level decline caused by well J-13 pumped at 90 gal/min for 10 years.



EXPLANATION

MODELED AREA

—0.1— LINE OF EQUAL WATER-LEVEL DECLINE AT THE END OF YEAR 10 OF THE SIMULATION-- Interval is 0.1 foot

• 1385 (J-13) NODE--Number represents model node number identifier, letter and number designation in parentheses represents well name.

Figure 2C.--Simulated water-level decline caused by well J-13 pumped at 84 gal/min and well J-12 pumped at 39 gal/min for 10 years.

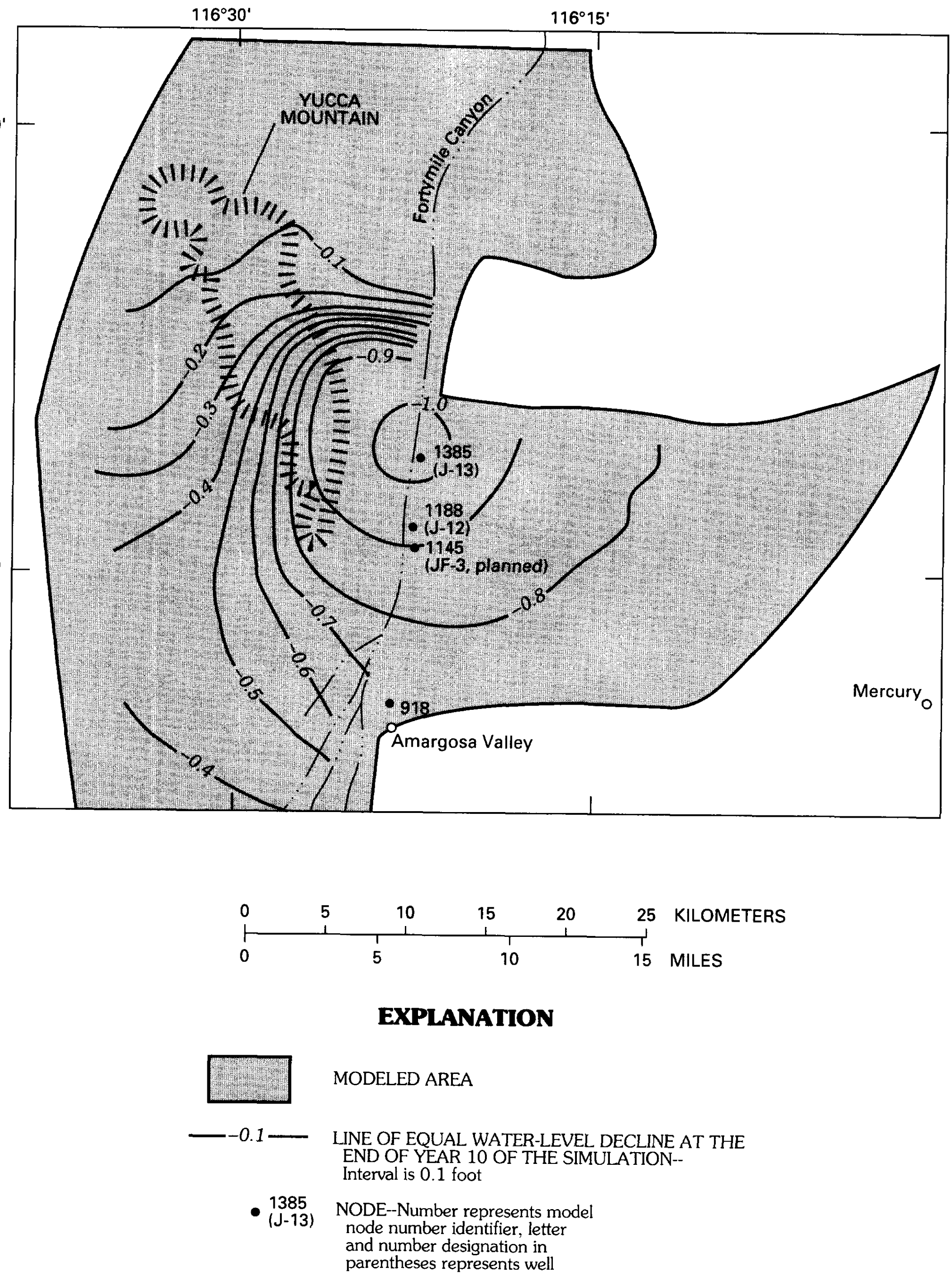


Figure 2D.--Simulated water-level decline caused by well J-13 pumped at 90 gal/min and well J-12 pumped at 39 gal/min for 10 years.

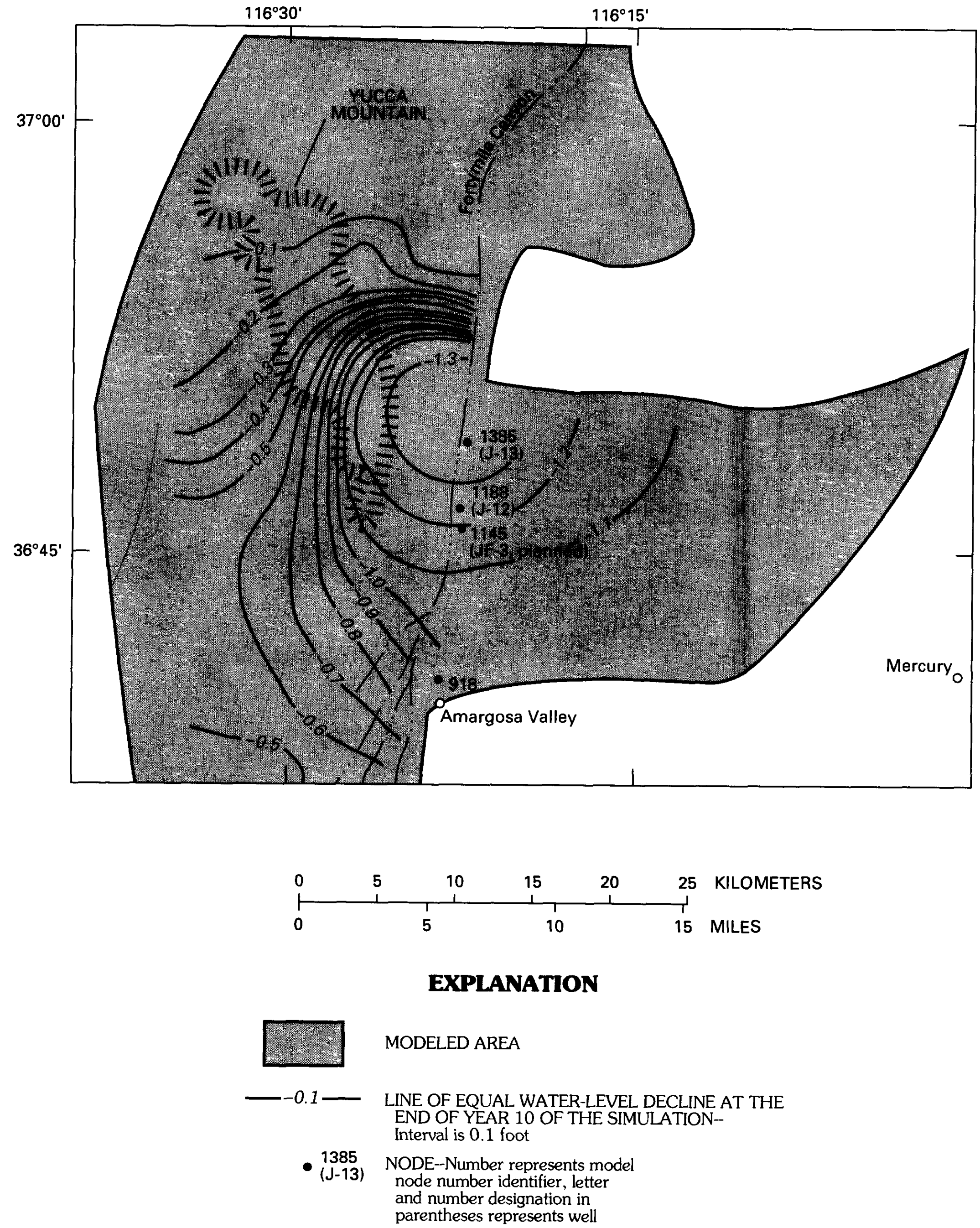
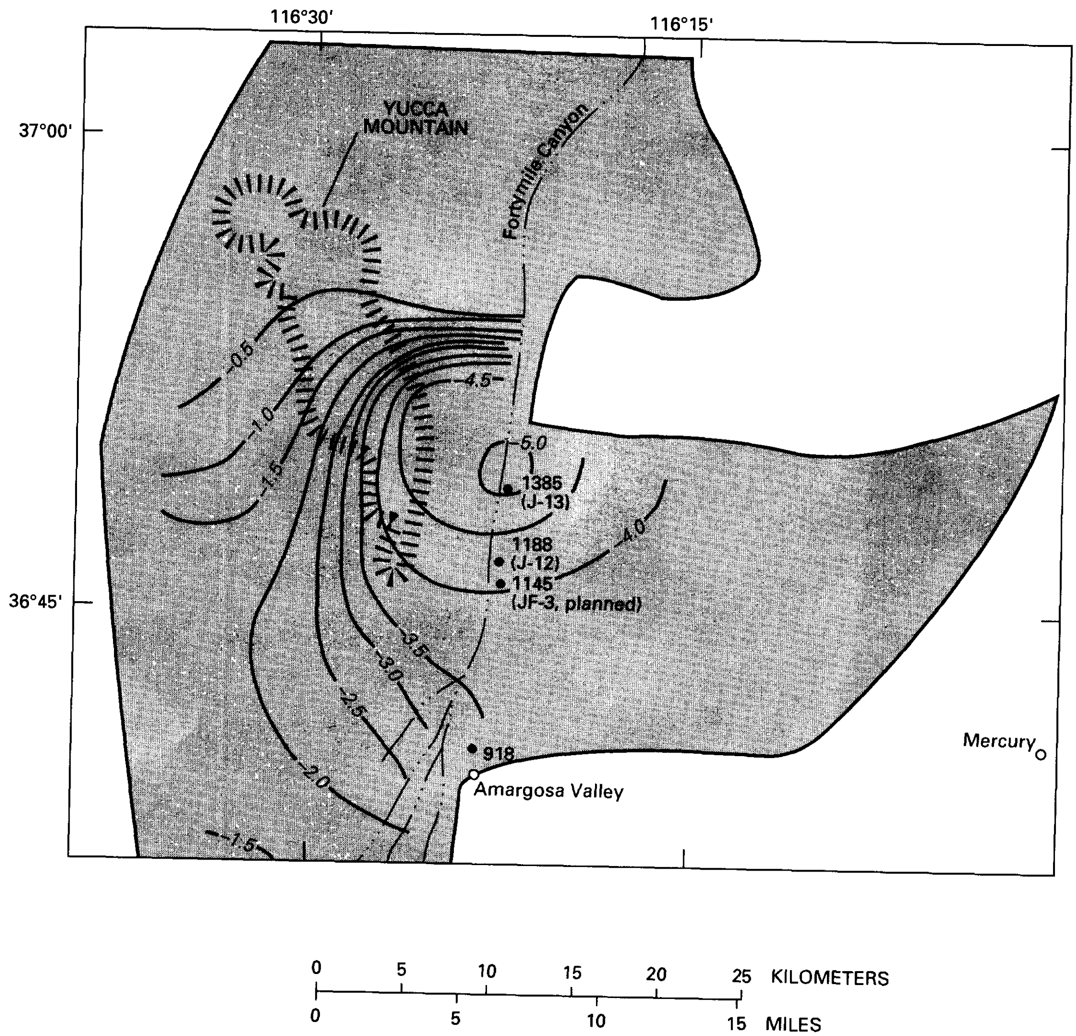


Figure 2E.--Simulated water-level decline caused by well J-13 pumped at 138 gal/min and well J-12 pumped at 39 gal/min for 10 years.



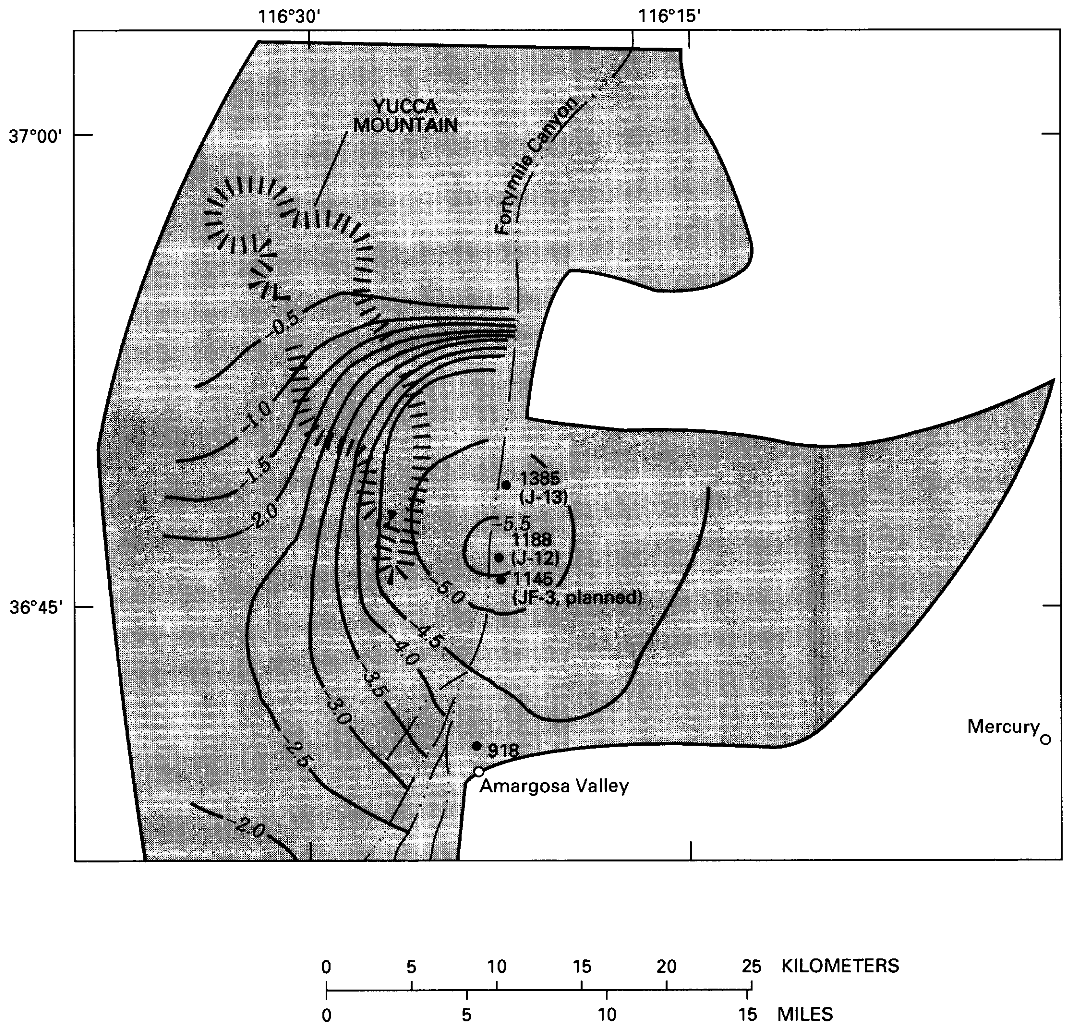
EXPLANATION

MODELED AREA

—— -1.5 —— LINE OF EQUAL WATER-LEVEL DECLINE AT THE END OF YEAR 10 OF THE SIMULATION-- Interval is 0.5 foot

• 1385 (J-13) NODE--Number represents model node number identifier, letter and number designation in parentheses represents well name.

Figure 2*F*.--Simulated water-level decline caused by well J-13 pumped at 630 gal/min for 10 years.



EXPLANATION

MODELED AREA

—— -1.5 —— LINE OF EQUAL WATER-LEVEL DECLINE AT THE END OF YEAR 10 OF THE SIMULATION--Interval is 0.5 foot

• 1385 (J-13) NODE--Number represents model node number identifier, letter and number designation in parentheses represents well name.

Figure 2G.--Simulated water-level decline caused by well J-12 pumped at 760 gal/min for 10 years.

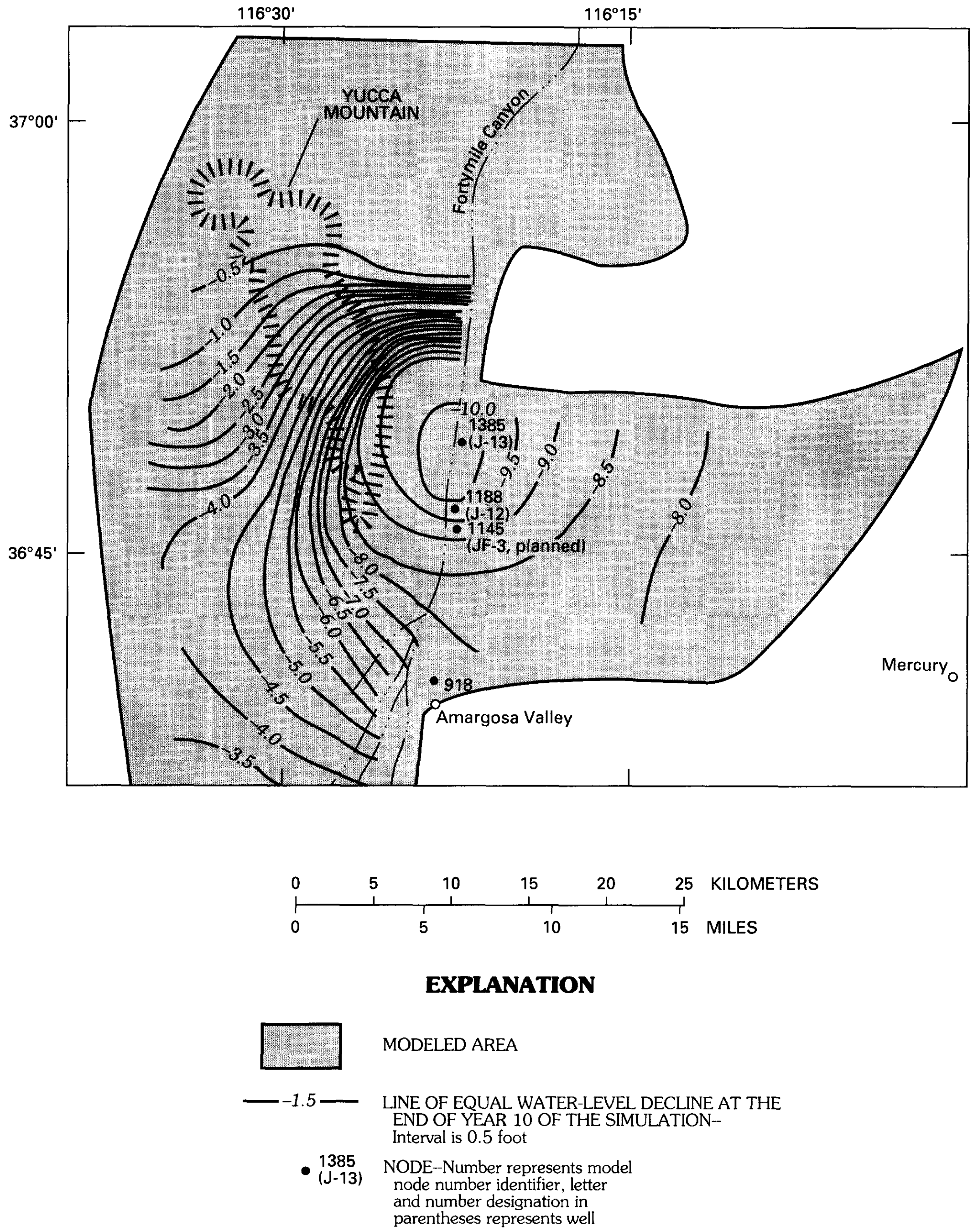


Figure 2H.--Simulated water-level decline caused by well J-13 pumped at 630 gal/min and well J-12 pumped at 760 gal/min for 10 years.

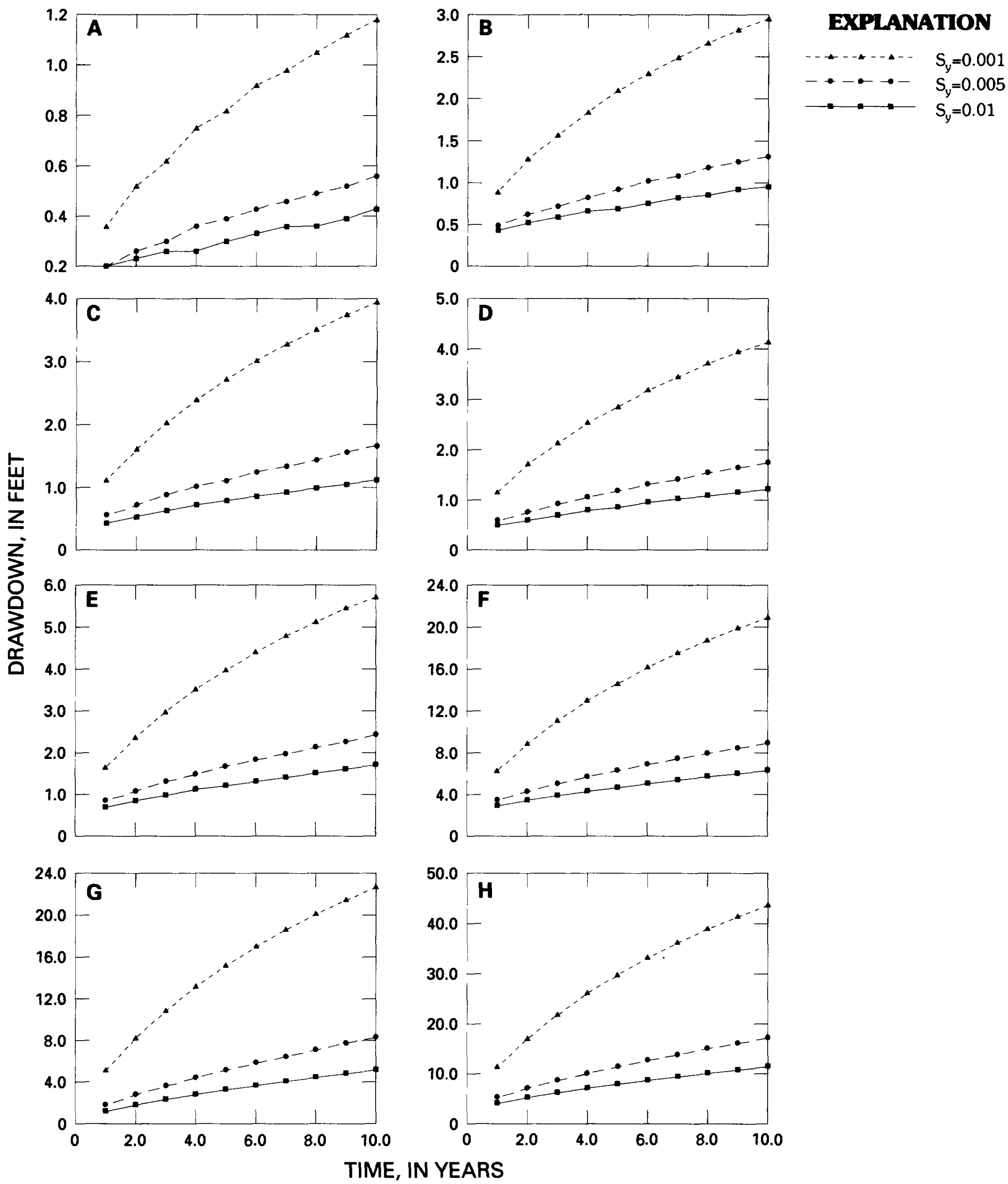


Figure 3.--Simulated drawdown as a function of time and specific yield at well J-13 for simulations *A* through *H*. Note variability in vertical axes to accommodate range in drawdown. For each graph, the top, middle, and bottom curves correspond to specific-yield values of 0.001, 0.005, and 0.01.

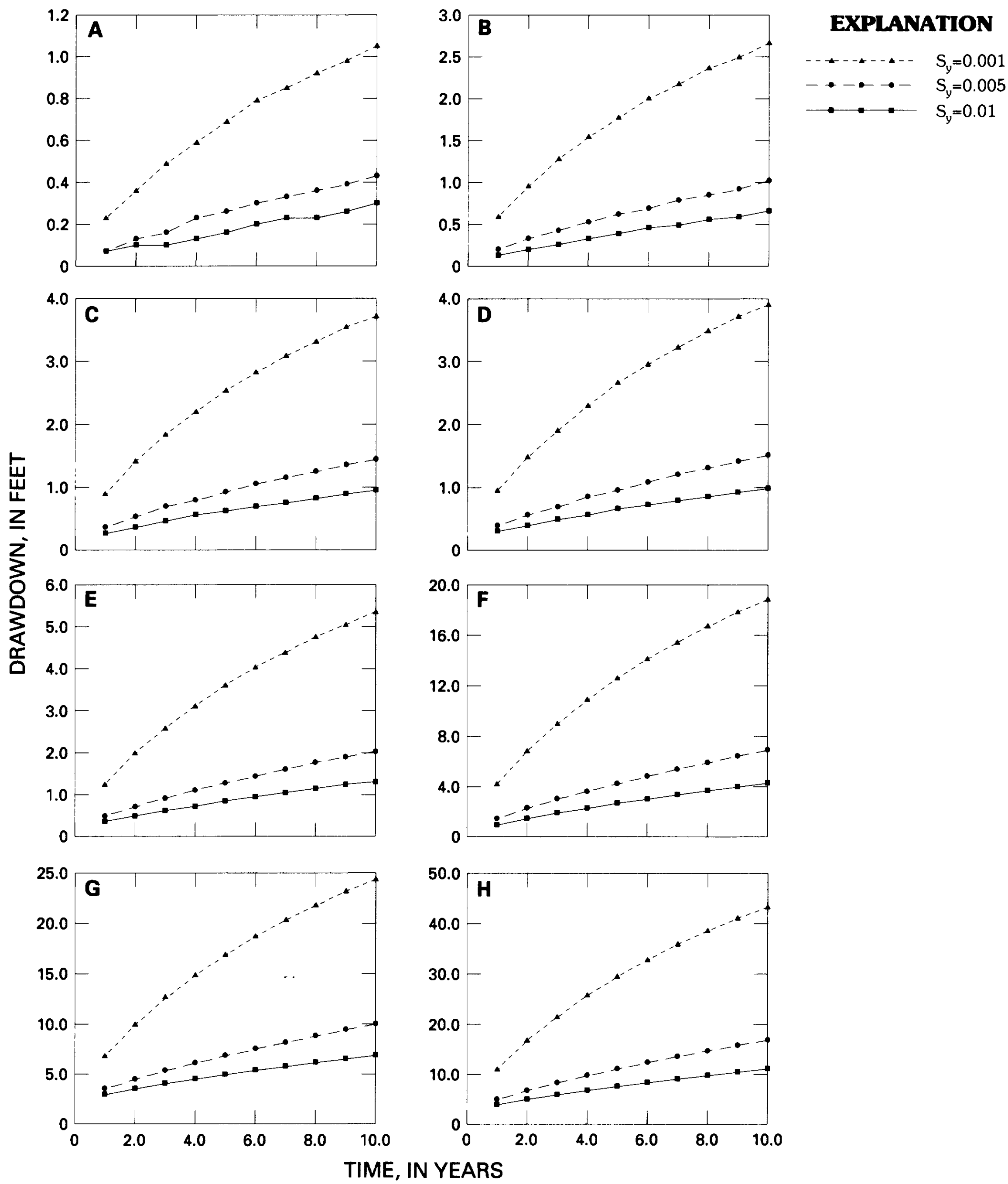


Figure 4.--Simulated drawdown as a function of time and specific yield at well J-12 for simulations *A* through *H*. Note variability in vertical axes to accommodate range in drawdown. For each graph, the top, middle, and bottom curves correspond to specific-yield values of 0.001, 0.005, and 0.01.

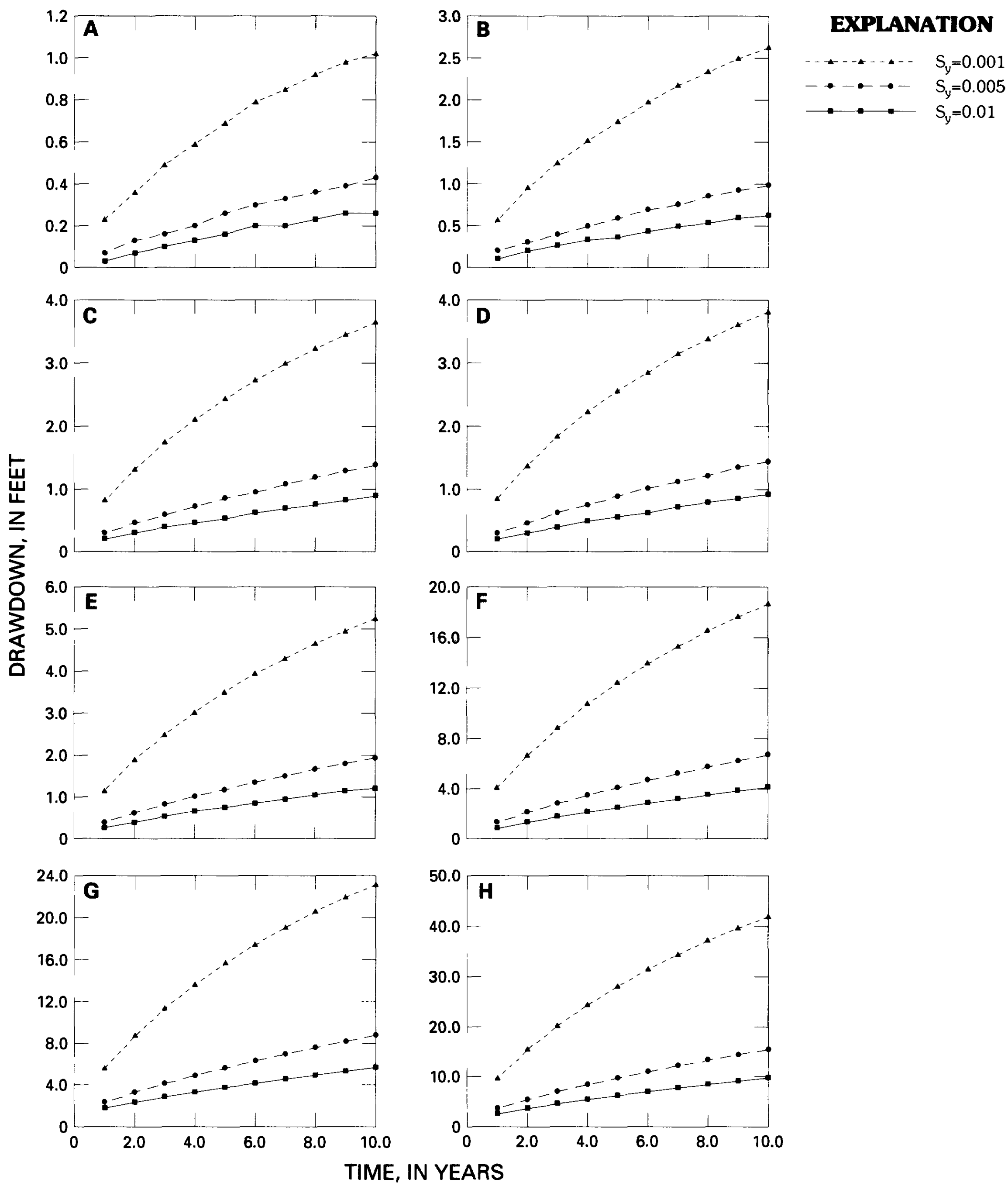


Figure 5.--Simulated drawdown as a function of time and specific yield at proposed monitor well JF-3 for simulations *A* through *H*. Note variability in vertical axes to accommodate range in drawdown. For each graph, the top, middle, and bottom curves correspond to specific-yield values of 0.001, 0.005, and 0.01.

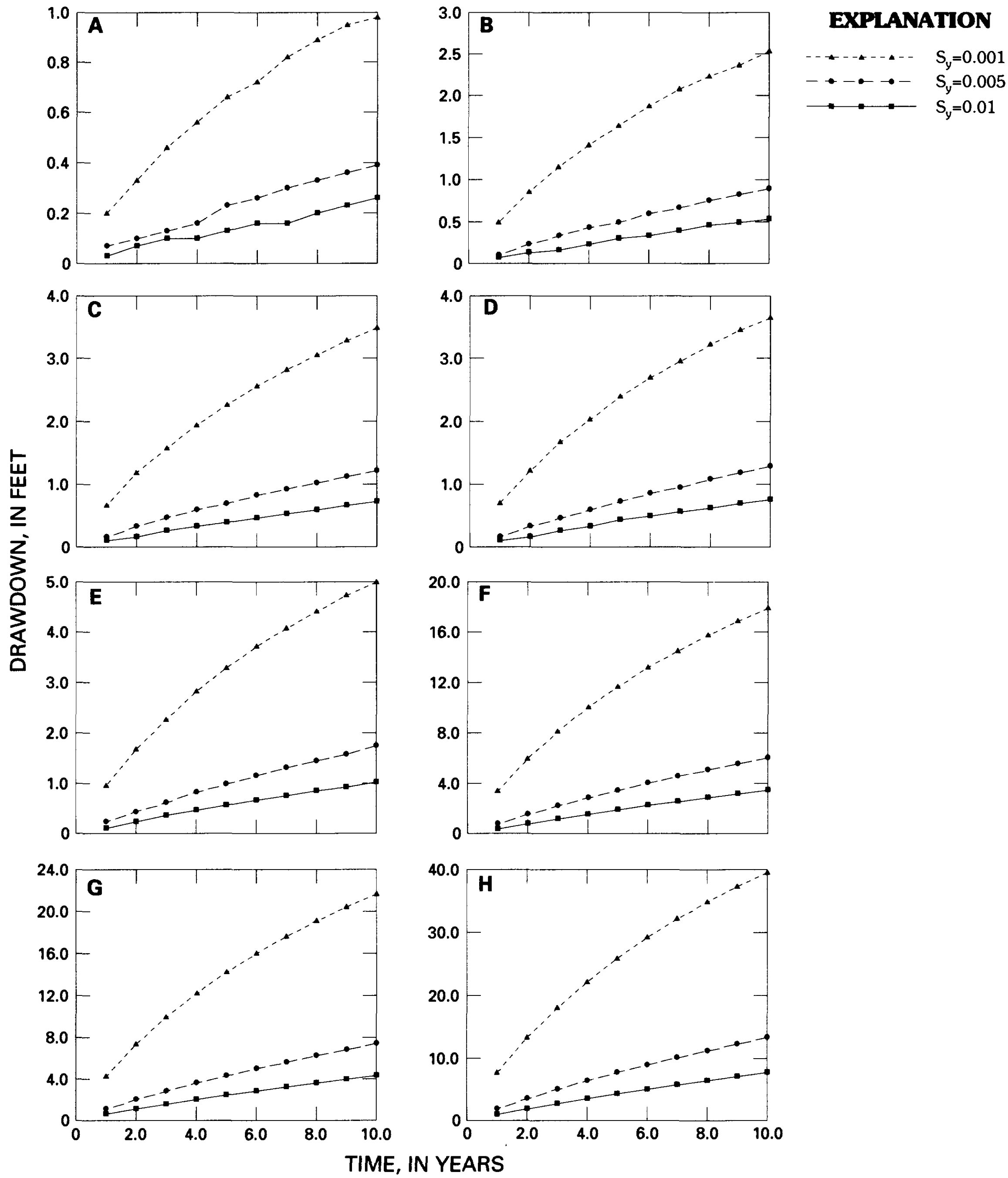


Figure 6.--Simulated drawdown as a function of time and specific yield near Amargosa Valley for simulations *A* through *H*. Note variability in vertical axes to accommodate range in drawdown. For each graph, the top, middle, and bottom curves correspond to specific-yield values of 0.001, 0.005, and 0.01.

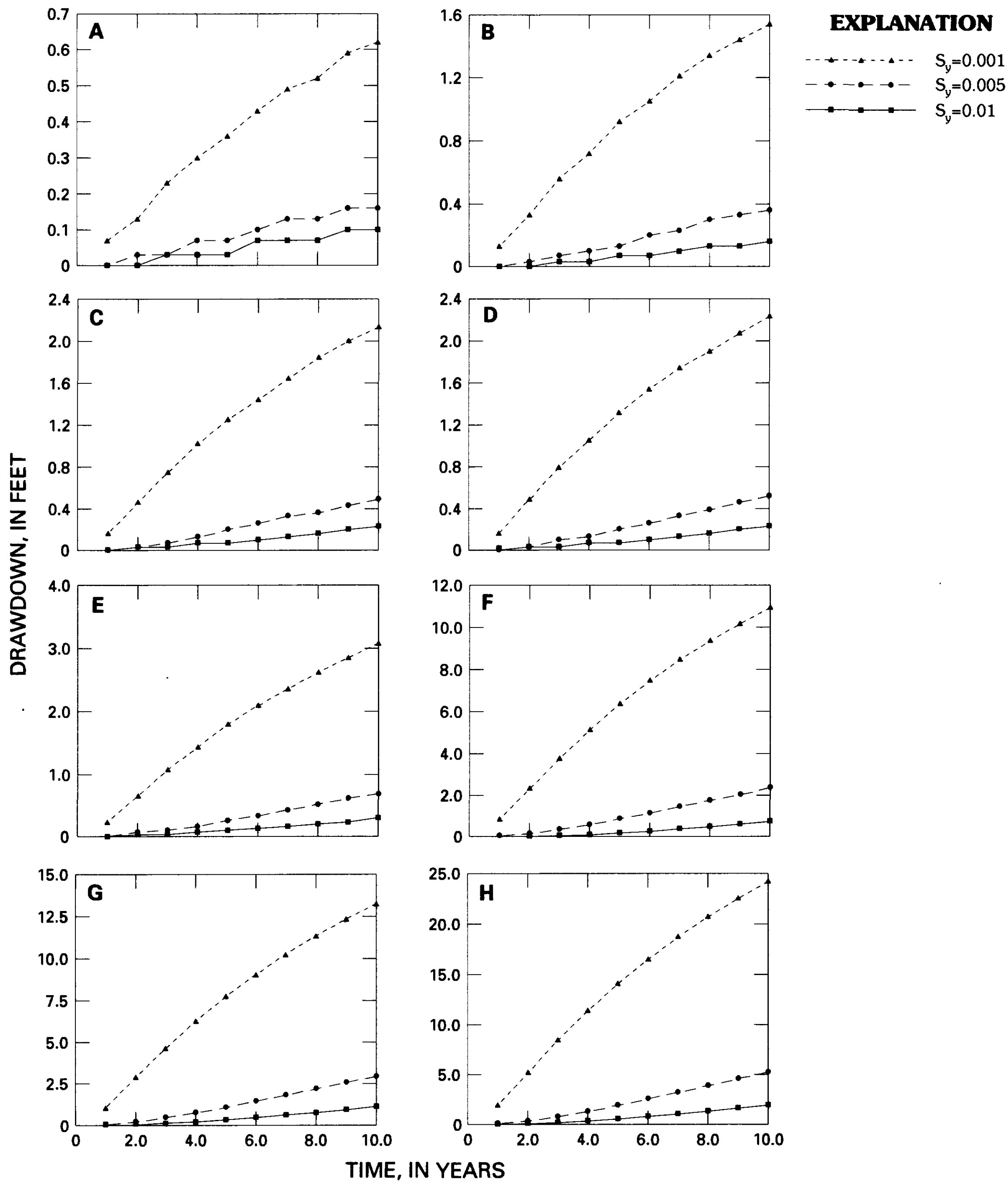


Figure 7.--Simulated drawdown as a function of time and specific yield near the Ash Meadows area for simulations *A* through *H*. Note variability in vertical axes to accommodate range in drawdown. For each graph, the top, middle, and bottom curves correspond to specific-yield values of 0.001, 0.005, and 0.01.

Table 2.--*Predicted drawdown, in feet, at five points within the flow system for all simulated withdrawal rates using a value of specific yield of 0.01*

[Withdrawal rates are from table 1. Node numbers are given in parentheses]

Node Location	Simulation							
	A	B	C	D	E	F	G	H
Well J-13 (1385)	0.43	0.95	1.15	1.21	1.71	6.30	5.15	11.42
Well J-12 (1188)	.30	.66	.95	.98	1.31	4.27	6.86	11.09
Proposed well JF-3 (1145)	.26	.62	.89	.92	1.21	4.10	5.68	9.71
Amargosa Valley (918)	.26	.53	.72	.75	1.02	3.45	4.33	7.74
Ash Meadows (716)	.10	.16	.23	.23	.30	.85	1.12	1.90

Plots of drawdown as a function of time for various points in the flow system are shown in figures 3 through 7, going from north (well J-13) to south (a point in the vicinity of the Ash Meadows area). Five finite-element nodes were selected within the flow system for detailed analyses of drawdown and correspond to the following locations: (1) well J-13 (node 1385); (2) well J-12 (node 1185); (3) proposed monitor well JF-3 (node 1145); (4) a point about 2 miles north of the town of Amargosa Valley (node 918); and (5) a point about 5 miles northwest of the Ash Meadows discharge area (node 716) (fig. 1). Monitor well JF-3 is discussed in the U.S. Department of Energy's monitoring plan for monitoring the effects of withdrawals from well J-13, and has not yet been constructed. For each of the five locations, eight graphs of drawdown are shown, corresponding to the eight simulated withdrawal rates. For each simulated withdrawal rate, three different values of specific yield (S_y) were used, 0.001, 0.005, and 0.01, and correspond to the top, middle, and bottom curves for each of the graphs shown in figures 3 through 7. The vertical axes of these graphs are variable, in order to allow for higher resolution of the drawdown plots for small withdrawal rates.

Drawdown is greatest at the pumped well for each simulation and increases with the rate of simulated withdrawal. At the end of 10 years, drawdown (fig. 3) at node 1385 (or well J-13) ranges from 0.43 ft (simulation A; S_y=0.01) to 43.6 ft (simulation H; S_y=0.001); at node 1188 (or well J-12), the corresponding range in drawdown is 0.30 to 43.2 ft (fig. 4). About one-half mile south of well J-12, the range in simulated drawdown at node 1145 (or proposed monitor well JF-3) is 0.26 to 41.8 ft (fig. 5). At node 918, located about 2 miles north of the town of Amargosa Valley, the simulated range in drawdown is 0.26 to 39.5 ft (fig. 6). The range in drawdown at node 716, located about 5 miles northwest of the Ash Meadows area is about 0.10 to 24.2 ft (fig. 7). A summary of the simulated drawdowns at the five locations after 10 years of withdrawals is shown in table 2 for each of the simulations using a specific yield of 0.01.

SUMMARY AND CONCLUSIONS

Simulations were made of the effects of pumped wells J-13 and J-12 in the vicinity of Yucca Mountain, NV using a two-dimensional, subregional, finite-element model of ground-water flow. These simulations were made to examine the spectrum of withdrawal rates that could be envisioned from pumping these wells, including the anticipated additional rate of 90 gal/min from well J-13 needed for site characterization work at Yucca Mountain by the U.S. Department of Energy.

Eight different withdrawal rates ranging from 36 gal/min (the minimum average for well J-13) to 1,390 gal/min (the maximum for both J-13 and J-12 combined) were used in conjunction with specific-yield values of 0.001, 0.05, and 0.01. Drawdown was estimated for a period of 10 years at five points within the flow system, and for the region as a whole at the end of 10 years of withdrawals at specified constant rates. Because the range in simulated withdrawal rate was large, the range in resultant drawdown was correspondingly large. The predicted drawdown after 10 years for the anticipated withdrawal rate of 90 gal/min from well J-13, based on a specific yield of 0.01 (which was considered to be a minimum value for the volcanic rock/alluvial aquifer system), was 0.95 ft at well J-13, 0.66 ft at well J-12, 0.62 ft at proposed monitor well JF-3, 0.53 ft at a point about 2 miles north of the town of Amargosa Valley, and 0.16 ft at a point about 5 miles northwest of the Ash Meadows area.

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